STUDY ON MECHANICAL PRETREATMENT PROCESS OF PALM OIL MILL EFFLUENT (POME)

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“I declare that this thesis is the result of my own research except as cited references. The thesis has not been accepted for any degree and is concurrently submitted in candidature of any degree”.

Signature	:…….....
Name of Candidate	:…….
Date	:…….

DEDICATION

In God I Trust.

Dedicated to all my beloved family especially to my father, mother, and brothers.

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ABSTRACT

Palm oil mill effluent (POME) has been identified as one of the major sources of aquatic pollution in Malaysia. Due to its high strength and economic importance with more than 330 palm oil mills in operation, Malaysia produces about 10.6 million tones of crude palm oil annually, accounting for 47% of the total world production, and concomitantly generates 27 x 10^6 m^3 POME. This highly polluting wastewater can therefore cause severe pollution of waterways due to oxygen depletion and other related effects. The presence of oil-waste makes the bio-degrading process of the effluents difficult as oil inherently difficult to disintegrate. The aim of the proposed process in this study is both the reduction of pollution caused by the wastes and the selective separations of several useful products that are present such as polyphenol. Pretreatment process was carried out by using high speed centrifuge which the suspended solids are removed. Through the pretreatment, it helps to reduce the viscosity up to 22.3% and the acidity of POME. In addition, it will clarify the POME by reducing its turbidity value up to 32.4% along with the improvement of POME quality by decreasing the BOD and COD values. The polyphenol compound, (+)-catechin in POME was tracked by HPLC and it can only be separated chemically or biologically.

Keywords: *Palm Oil Mill Effluent (POME), Pretreatment, High Speed Centrifuge, Polyphenol, High Pressure Liquid Chromatography (HPLC).*

ABSTRAK

Sisa buangan dari kilang memproses kelapa sawit (POME) telah dikenalpasti sebagai salah satu daripada sumber utama penyebab kepada pencemaran air di negara Malaysia. Berdasarkan kepada potensi yang tinggi serta kepentingan ekonomi, lebih 330 buah kilang memproses kelapa sawit beroperasi di Malaysia dimana setiap tahun Malaysia mengeluarkan sebanyak 10.6 million tan minyak kelapa sawit , dan Malaysia menyumbang 47% kepada eksport minyak sawit dunia. Seiring dengan itu, sebanyak 27 x 10_6 m_3 POME terhasil dari kilang-kilang yang memproses kelapa sawit di Malaysia. Sisa buangan yang mencemarkan air ini secara tidak langsung boleh menyebabkan pencemaran laluan air dimana ianya mampu mengurangkan kepekatan oksigen didalam air dan merupakan penyumbang kepada masalah-masalah sampingan yang lain.Dengan kehadiran minyak sebagai bahan pencemar, proses bio-degarasi terhadap sisa buangan tersebut menjadi rumit kerana molekul minyak amat sukar untuk diuraikan secara semulajadi. Jadi, tujuan utama ialah untuk mengurangkan kadar pencemaran yang disebabkan oleh POME dan mengasingkan secara pilihan terhadap produk berguna yang terdapat di dalam POME contohnya seperti polyphenol. Proses pra rawatan dilakukan dengan menggunakan mesin pengempar yang berhalaju tinggi bertujuan untuk mengasingkan pepejal yang terampai. Melalui proses pra rawatan ini telah membantu mengurangkan kelikatan sebanyak 22.3% serta mengurangkan tahap keasidan POME. Disamping itu, tahap kejernihan juga dapat ditingkatkan sebanyak 32.4% sejajar dengan peningkatan kualiti yang di nilai melalui penurunan nilai BOD dan COD. Komposisi polyphenol yang terdapat dalam POME dari jenis (+)-catechin dapat dikesan dengan analisis HPLC dan ianya tidak dapat diuraikan secara mekanikal tetapi ianya hanya dapat di pisah dan diuraikan melalui tindakbalas kimia atau melalui kaedah biologi.

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LIST OF SYMBOLS

POME = Palm Oil Mill Effluent

HPLC = High Pressure Liquid Chromatography

BOD = Biological Oxygen Demand

COD = Chemical Oxygen Demand

RPM = Rotation per minute

NTU = Nephelometric Turbidity Units

DO = Dissolved Oxygen

D_1 = initial DO of the diluted wastewater sample about 15 min after preparation

D_2 = final DO of the diluted wastewater sample after incubation for 5 days

P = decimal fraction of the wastewater sample used

ppm = Part per million

CHAPTER 1

INTRODUCTION

1.1 Introduction

Palm oil is a form of edible vegetable oil obtained from the fruit of the oil palm tree. Palm oil is a natural food that has been consumed for more than 5,000 years. Palm oil is produced from the fruit of the oil palm, or Elaeis Guinnesis tree, which originated in West Guinea. While the tree was introduced into other parts of Africa, South East Asia and Latin America during the 15th century, it was first introduced 1870 as an ornamental plant. Large commercial planting and cultivation of the plant in Malaysia did not begin until the mid- 1990's [19]. The world's largest producer and exporter of palm oil today is Malaysia, producing about 47% of the world's supply of palm oil. [1]

Oil palm is an important crop in Malaysia. Approximately 11.9 million tones of crude palm oil (CPO) were produced that amounted to RM 14.79 billion in the year 2002. The process to extract the oil requires significantly large quantities of water for steam sterilizing the palm fruit bunches and clarifying the extracted oil. It is estimated that for one tone of crude palm oil produced, 5-7.5 tones of water are required, and more than 50% of the water will end up as palm oil mill effluent (POME) The complete palm oil and palm kernel oil extraction process flow is illustrated in Figure 1.1. Thus, while enjoying a most profitable commodity, the adverse environmental impact from the palm oil industry cannot be ignored. Based on the current annual rate of oil palm harvesting, some 4.5 million metric tones of effluents are being produced and discharged into the rivers. POME is a colloidal suspension of 95-96% water, 0.6-0.7% oil and 4-5% total solids including 24% suspended solids originating from the mixture of a sterilizer condensate, separator sludge and hydro cyclone wastewater . The raw or partially treated POME has an extremely high content of degradable organic matter, which is due in part to the presence of unrecovered palm oil .POME characteristic and standard discharge

limit is illustrated in Table 1.0. In order to regulate the discharge of effluent from the crude palm oil industry as well as to exercise other environmental controls, the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Order, 1977, and the Environment Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1977, were promulgated under the Environmental Quality Act, 1974. Due to these factors, the palm oil industry faces the challenge of balancing the environmental protection, its economic viability and sustainable development. There is an urgent need to find a way to preserve the environment while keeping the economy growing .[1]

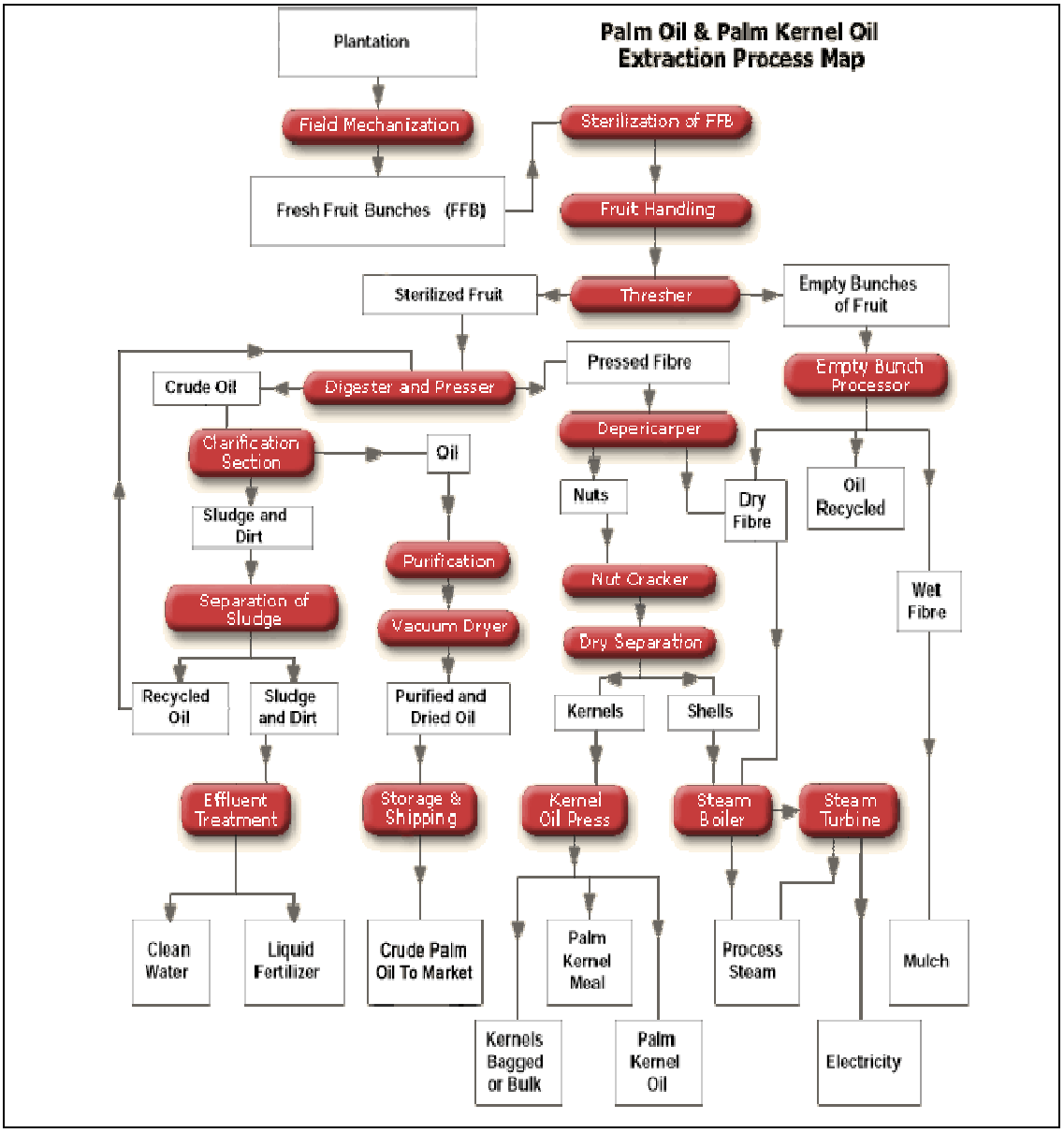
This highly polluting wastewater can therefore cause severe pollution of waterways due to oxygen depletion and other related effects. The presence of oil-waste makes the bio-degrading process of the effluents difficult as oil inherently difficult to disintegrate; hence this will lead to ruin the natural river or lake ecosystem [5]**.** But a few recent studies have been trickling that single tropical oil out of saturated fat milieu, palm oil contains components with nutritional and beneficial health properties. These phyto nutrients include water soluble antioxidants , like phenolic acids and flavonoids which generally known as a powerful free radical scavenger better than vitamins C,E and beta-carotene to prevent skin aging and inhibits UV radiation, enhance capillary strength and vascular function, penetrate the blood-brain barrier to help protection of the brain and nerve tissue from oxidation , alleviate PMS problems, bruising, edema from injury or trauma, varicose veins, leg swelling and retinopathy [16]**.** There are as many as 5 mg of antioxidant polyphenols in every 10 grams of palm oil.

Table 1.1: *Characteristics of POME and its respective standard discharge limit by the Malaysian Department of the Environment* [1]

PARAMETERS	CONCENTRATION mg/L	STANDART LIMIT mg/L
pH	4.7	5-9
Oil and grease	4000	50
BOD	25000	100
COD	50000	-
Total Solids	40500	-
Suspended solids	18000	400

Total nitrogen	750	150

Figure 1.1: *The complete palm oil and palm kernel oil extraction process flow* [26]



Therefore, the main issue in this case was to find ways to make use of palm oil waste effluent in the wise condition which was described as a very important step forward in environmental conservation and technological advancement which could benefit both the environment and the public.

1.2 Objective of the study

The main objectives of this preliminary study are:

1. To study the mechanical pretreatment process for Palm Oil Mill Effluent (POME) and recovery polyphenol compound in pretreated POME.

2. To carry out analysis on the quality and parameters involved in the mechanical process through POME pretreatment process.

1.3 SCOPE OF THE STUDY

For the purpose in determining the optimum method of mechanical process in pretreatment of POME, it is suggested high speed centrifuge is used. High speed centrifuge is chosen because of its easy maintenance, easy to handle, low cost and it is ideal equipment for solid-liquid separation and its ability operating at a very high centrifugal gravity treating a lab scale sample. The quality of pretreated POME can be determined by making analysis of the Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). The BOD and COD analysis can be carried out by using specific analysis equipment. In addition, the turbidity, pH, and viscosity will be measured before and after the pretreatment to know how far the POME is recovered through the centrifugation treating system. Instead of doing analysis on parameters of the pretreated POME quality, other important parameters are also measured; parameters related to the centrifugation treating system. The parameters measured include the rotation per minute (rpm) and the relationship between the operating time intervals. For this purpose, the different rpm will be applied from minimum rpm to maximum rpm. The volatile compound of polyphenol in pretreated POME can be tested by High

Pressure Liquid Chromatography (HPLC). For this purpose, (+)-catechin , one of the volatile compound of polyphenol contains in POME will be analyzed .

CHAPTER 2

LITERATURE REVIEW

Palm Oil Mill Effluent (POME)

Introduction

Palm oil is a form of edible vegetable oil obtained from the fruit of the oil palm tree. There are two species of oil palm, the better known one is the one originating from Guines, Africa and was first illustrated by Nicholaas Jaquin in 1763, hence its name, *Elaeis guineensis* Jacq [19]. The process to extract the oil requires significantly large quantities of water for steam sterilizing the palm fruit bunches and clarifying the extracted oil. For every one tone crude, 7.5 tones water is required .About 4.0 million will end up as palm oil mill effluent (POME), reddish brown in color.

Figure2.1: Fresh Fruit Bunch (FFB) and Palm fruit [28]

The palm oil industry has been expanding rapidly in the last three decades in Malaysia,with the planted area increasing by more than 11 fold from 291,000 ha in 1970 to 3,313,000 ha in 1999 . Concomitantly, the number of palm oil mills has also grown from 122 in 1977 to 334 in 1999, having a total processing capacity of 69 million tonnes fresh fruit bunches (FFB) per year. Currently, Malaysia produces about 57 million tonnes of FFB annually, from which 10.6 million tonnes of crude palm oil and 1.3 million tonnes of palm kernel oil are extracted. In 1999, Malaysia exported 8.9 million tonnes of palm oil, and is currently ranked as the largest producer of palm oil in the world, accounting for 52% of the total world production. These figures put into perspective the importance of the palm oil industry in the overall industrial development of Malaysia. The process to extract oil from the FFB requires voluminous amount of water, mainly for sterilising the fruits and for oil clarification, resulting in the discharge of about 2.5 m3 of effluent per tonne of crude oil processed . Thus in 1999, a total of about 26.5 million m3 of effluent was generated from the Malaysian palm oil industry. Fresh palm oil mill effluent, or POME as it is popularly known, is an acidic brownish colloidal suspension characterised by high contents of organics and solids, and is discharged at a temperature of 80-90°C . It has been estimated that POME contributes to about 30% of the total biochemical oxygen demand (BOD) load exerted on the

Malaysian aquatic environment. As one of the major sources of pollution, POME was among the first waste types to be singled out for statutory control. [18]

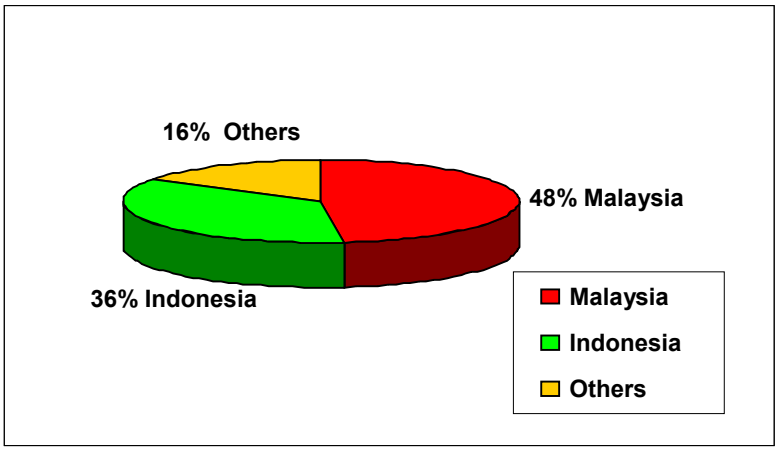


Figure 2.2: World's Supply of Palm Oil in Year 2000

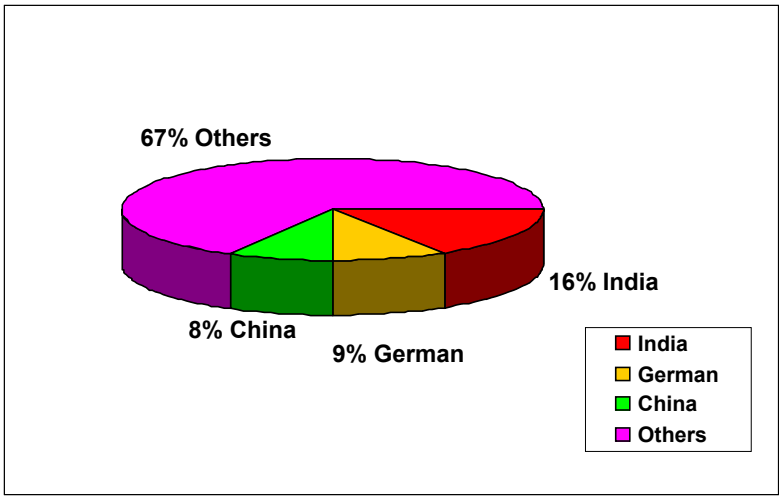


Figure 2.3: World's Largest Importer of Palm Oil in Year 2000

Table 2.1 : Characteristics of raw POME and the regulatory discharge limits [18]

Parameter	**Value(2)**	**Regulatory discharge limit(3)**

Temperature (°C)	80-90	45
pH	4.7	5.0 - 9.0
Biochemical oxygen demand (BOD3, 3 days at 30°C(4))	25,000	100 (50)(5)
Chemical oxygen demand (COD)	50,000	-
Total solids (TS)	40,000	400
Total suspended solids (TSS)	18,000	-
Total volatile solids (TVS)	34,000	50
Oil and grease (O&G)	4,000	150(6)
Ammonia-nitrogen (NH3-N)	35	200(6)
Total Kjeldahl nigrogen (TKN)	750	

(1)Ref. [4].
(2)All values, except pH and temperature, are expressed in mgL-1.
(3)Ref. [5].
(4)Statutory incubation conditions.
(5)This additional limit is the arithmetic mean value determined on the basis of a minimum of four samples taken at least once a week for four weeks consecutively.
(6)Value of filtered sample.

	ADVANTAGES	DISADVANTAGES
1	Produce biogas- methane gas	- Difficult to disintegrate by bacteria.
2	Produce animal feed supplement.	-Ruin the river or lake ecosystems
3	Used for fertilizer	-unpleasant smell
4	**Rich in phytonutriens (antioxidant)**	

Table 2.2: Advantages and Disadvantages Of POME

Polyphenol as an Antioxidant

2.2.1 Introduction

Polyphenols are a large and diverse class of compounds, many of which occur naturally in a range of food plants. Polyphenols are a group of plant chemical substances, characterized by the presence of more than one phenol group per molecule. Polyphenols are responsible for the coloring of some plants—for example, the color of leaves in the autumn. The flavonoids are the largest and best-studied group of these. A range of plant polyphenols are either being actively developed or currently sold as dietary supplements and/or herbal remedies. However not all polyphenols and not all actions of individual polyphenols are necessarily beneficial. Some have mutagenic and/or pro-oxidant effects, as well as interfering with essential biochemical pathways including topoisomerase enzyme activities, prostanoid biosynthesis and signal transduction. There is a very large amount of in vitro data available, but far fewer animal studies, and these are not necessarily predictive of human effects because of differences in bacterial and hepatic metabolism of polyphenols between species. Epidemiological studies suggest that high green tea consumption in the Japanese population and moderate red wine consumption in the French population may be beneficial for heart disease and cancer, and these effects may relate to specific polyphenols.

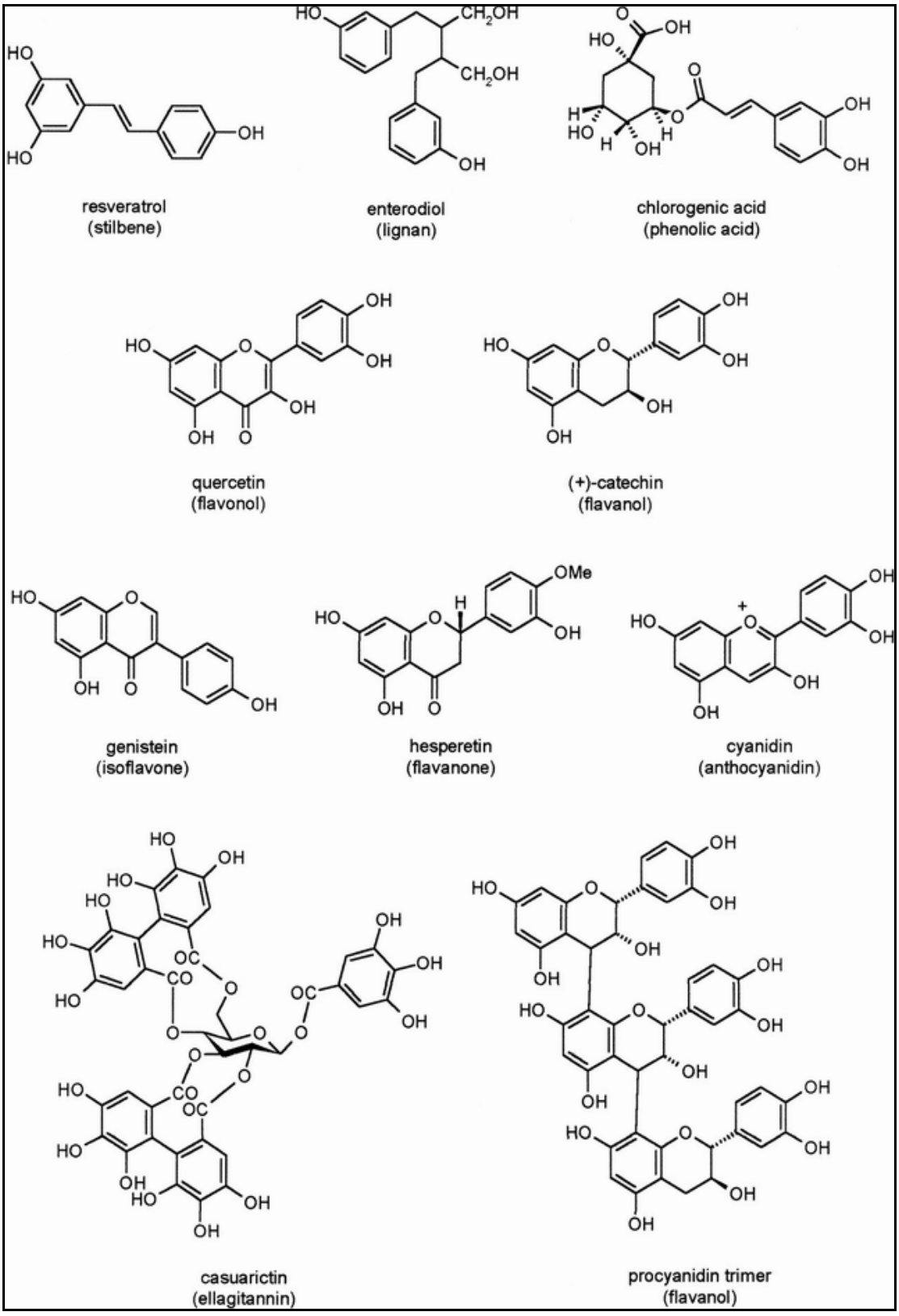


Figure 2.4: The Structure of Polyphenol's Chemical Compounds. [30]

2.2.2 Phenolic Compounds

Polyphenol has a characteristic aromatic ring with an hydroxyl group attached to it. About 10 000 of them exists. Some are water soluble, others are soluble in organic solvents and others are large, insoluble polymers. Chichimec pathway participates in the biosynthesis of most plant phenolics. In the pathway, simple carbohydrates precursors (PGA and phosphoenolpyruvate (PEP) are converted into aromatic amino acids. This pathway is found in plants, bacteria and fungi but is not found in animals. Animals have no way of synthesizing the three aromatic amino acids – phenylalaninine, tyrosine, and tryptophan. Most secondary compounds in plants are derived from phenylalaninine. An ammonia group is removed from phenylalanine to form cinnamic acid. This reaction is catalyzed by phenylalanine ammonia lyase (PAL) [27].

2.2.3 Source of Polyphenol

(a)

(b)

(c)

(d)

(e)

(f)

Figure 2.5: (a) Coffee Beans [20] (b) Olive Fruits [25] (c) Palm Fruit [19] (d) Grape seeds [29] (e) Green Tea [24] (f) Cocoa Fruit [23]

2.2.4 Advantages of Polyphenol as Antioxidant

Studies from various research suggest that polyphenols are actually a powerful type of antioxidant with potential health benefits. Sources of polyphenols include green tea, white tea, red wine, olive oil, dark chocolate, and pomegranates.These antioxidants help prevent the spread of cancer by targeting molecular pathways that shut down the proliferation and spread of tumor cells, as well as inhibiting the growth of tumor nurturing blood vessels. Studies have shown that polyphenols prevent cancers of colon, esophagus, liver, stomach, lung, breast, pancreas, and skin. [16]

	INDICATIONS OF POLYPHENOL
1	Prevent skin aging
2	Inhibits UV radiation
3	Enhance capillary strength and vascular function
4	Alleviate PMS problems
5	Alleviate bruising, edema from injury or trauma
6	Help protection of the brain and nerve tissue from oxidation

Table 2.3 **:**The Benefits of Polyphenol as an Antioxidant to Human

2.3 High Speed Centrifuge

2.3.1 Centrifuge Theoretical Performance Predictions [9]

1. If a particle of mass ***m*** is rotating with an angular velocity ***ω*** at a radius ***r*** from its centre of rotation it is acted upon by a centrifugal force $\boldsymbol{mr\ \omega^2}$ in the radial direction.
2. In sedimenting centrifuge the centrifugal acceleration $r\omega^2$ is very much larger than the acceleration due to gravity ***g*** (so gravity forces are neglected) and the ratio of $\boldsymbol{r\omega^2/g}$ is used as a measure of the separating power of the machine.
3. The centrifugal force is large enough to overcome the Brownian diffusion forces which in gravity sedimentation hinder or prevent settling of very fine particles.
4. Fine particles moving in liquids have low Reynolds number (in the region of viscous resistance), it is common to assume, in describing particle motion in rotating liquids that Stoke's law holds.

Equation for centrifugal force:- [2]

In circular motion the acceleration due to the centrifugal force is

$$\boldsymbol{a_e = r\omega^2} \qquad (1)$$

a_e is the acceleration from centrifugal force in m/s²
r is a radial distance from centre of rotation in m
ω is angular velocity in rad/s

The centrifugal force F_c in N acting on the particle is given by

$$\boldsymbol{F_c = ma_e = mr\ \omega^2} \text{ (SI unit)} \qquad (2)$$

Often rotational speeds are given a N rev /min and

$$\boldsymbol{\omega = \frac{2\pi N}{60}} \qquad (3)$$